5. Design Input—Materials Properties for Mechanistic Design

In one way or another, moisture affects the mechanical properties of the pavement structure more than anything else. Control of moisture flow within, through, and around the pavement structure therefore influences the pavement structure design process more than any other consideration. In most cases, the moisture content of an unbound pavement layer is the chief determiner of strength. Both AKFPD design programs indirectly account for moisture contents of unbound layers. However, in addition to using the AKFPD program properly, the designer must ensure that the pavement's structural layers actually achieve and retain their intended strength properties. The designer must provide culverts, ditches, cross slopes, subdrains, and permeable layers as required to minimize water in the pavement structure. Good drainage design is critical to all pavement designs. Chapter 8 presents additional comments on drainage design.

5.1. Materials Properties—Recommended Presumptive Values for New Construction and Reconstruction Designs

5.1.1. Resilient Modulus (M_R) Values

M_R should not be confused with another measure of dynamic elastic modulus known as the complex modulus (E*). E* is not presently used in DOT&PF mechanistic design methods. Usually the layer resilient modulus values (M_R) for materials used in new construction are not known. You may use presumptive modulus values as shown in Tables 5-1 and 5-2. Material containing excess fines may cause significant thaw weakening of the overlying pavement structure. As a design quality control measure, seek concurrence in the selected modulus values from regional or headquarters pavement design experts.

Table 5-1. Pavement Layer Moduli (ksi)

Material Type	P_{200}	Spring	Summer & Fall	Winter
Asphalt Concrete	—	755	510	1,500
Aggregate Base	<6%	45	50	100
Selected Material Type A	<6%	25	35	90
Selected Material Type B	<10%	15	30	80
Selected Material Type C & Subgrade	<30%	50	10	10

Table 5-2. Pavement Layer Moduli (with excess fines) (ksi)

Material Type	P_{200}	Spring	Summer & Fall	Winter
Asphalt Concrete	—	755	510	1,500
Aggregate Base & Selected Material Type A	<10%	20	40	95
Selected Material Type B	<10%	15	30	80
Selected Material Type C	<18%	5	10	50
Subgrade	>30%	45	10	10

Another resource is available for quickly estimating the M_R for asphalt concrete materials. Install and run Paveinfo03 from the CD containing AKPFD, and follow the on-screen example regarding necessary input values. The equation that Paveinfo03 uses for calculating the modulus is explained in Witczak and Fonseca, 1996.[14]

5.1.2. Resilient Modulus Values for Stabilized Base Course Materials

Table 5-3 contains typical modulus values for stabilized base course materials.

Table 5-3. Stablized Base Course Moduli (ksi)

Material Type	Spring	Summer & Fall	Winter
RAP (50:50)[1]	80	80	115
CAB, 3% Emulsion[1]	75	75	115
CAB, 4% Asphalt[2]	250	250	1500

1. lightly bound: use Ullidtz
2. heavily bound: use TAI

Design with lightly bound asphalt-treated base courses (using CSS-1 emulsion additive) using the mechanistic design procedure and by controlling the vertical compression stress at the top of the treated base and horizontal tensile strain at the bottom of the asphalt concrete pavement layer.

Design with heavily bound asphalt-treated base courses (containing ≥ 4% asphalt cement) using the mechanistic design procedure and by controlling the horizontal tensile strain at the bottom of the asphalt-treated base course and the asphalt concrete pavement layer.

Verify the validity of presumptive modulus values with regional or headquarters Materials section personnel.

5.1.3. Handling Stress Sensitivity

Stress sensitivity need not be accounted for in mechanistic pavement designs for the Alaska DOT&PF.

5.1.4. Poisson's Ratio Values

Table 5-4 contains recommended Poisson's ratios for various pavement structure materials. As a design quality control measure, seek concurrence in the selected Poisson's ratio values from regional or headquarters pavement design experts. Slight variations will not alter the design.

Table 5-4. Poisson's Ratio Values

Material Type	Poisson's Ratio (μ)
Asphalt Concrete	0.30
Aggregate Base	0.35
Selected Material Types A and B	0.40
Selected Material Type C	0.45
Subgrade Materials	0.45

5.2. Materials Properties—Laboratory Testing to Determine Values for New Construction and Reconstruction Designs

Much of the mechanistic pavement design work done for DOT&PF relies on presumptive M_R Poisson's ratio values (see Section 5.1), although backcalculated values for M_R are often obtained based on deflection test data for overlay design work (see Section 5.3). This section provides guidance for those rare design situations where laboratory testing may be required. Testing might be required, for example, for designs involving unusual or experimental material types not listed in the Section 5.1 tables.

5.2.1. Resilient Modulus Values

For determining M_R of unbound soils (including subgrade soils) or unbound or lightly bound bases or subbase materials, use AASHTO T 292-97 (2000) *Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Material*.

For determining M_R of asphalt-bound materials such as asphalt concrete or other heavily asphalt-cemented pavement or base materials, use ASTM D4123-82 (1995) *Standard Test Method for Indirect Tension test for Resilient Modulus of Bituminous Mixtures.*

For heavily bound pavement, base, or subbase materials with a cementing agent other than asphalt, consult regional or headquarters Materials personnel for a recommended test method.

5.2.2. Resilient Modulus Values for Stabilized Base Course Materials

Use test methods indicated in 5.2.1.

5.2.3. Handling Stress Sensitivity

Stress sensitivity need not be accounted for in mechanistic pavement designs for the Alaska DOT&PF.

5.2.4. Poisson's Ratio Values

For all normal pavement design work the designer will use presumptive Poisson's ratio values. Table 5.3 contains recommended Poisson's ratios for common pavement structure materials. As a design quality control measure, the designer should seek concurrence in the selected Poisson's ratio values from regional or headquarters pavement design experts. Also solicit materials expertise for determining Poisson's ratio values for unusual materials.

5.3. Materials Properties—Values Determined From Field Tests for Overlay Designs

5.3.1. Backcalculation Program

DOT&PF recommends the backcalculation program ELMOD, developed by Dynatest Consultants Inc. Back-calculation of layer modulus values should be done only by personnel with experience in performing back-calculations—regional pavement design engineers or equivalent.

Poisson's ratios for various pavement structure layers are those shown in Table 5-4.

The minimum asphalt concrete thickness for which a modulus can be backcalculated is 3.5 inches, because of the plate size on the falling weight deflectometer. For thinner layers, the asphalt concrete pavement must be cored and tested in the laboratory, or suggested moduli in Table 5-1 can be used. Adjust the measured or backcalculated moduli to the seasonal field temperature using an equation such as on page 16 of The Asphalt Institute Research Report No. 82-2, *Research and Development of Thickness Design Manual.*

5.3.2. Selection of Design Moduli

Select the design modulus for a given pavement structure layer at the 84th percentile ranking value. Most soil properties follow a log normal distribution. This corresponds to a 95th percentile confidence level of a normal distribution. This is done by sorting the modulus values with the lowest ranked as zero and the highest 100%. Select the closest value to the 84th percentile ranking.

5.3.3. Deflection Testing

DOT&PF currently uses a falling weight deflectometer to measure the dynamic deflection for pavement rehabilitation design.

If deflection test data will be used in back-calculating modulus values for highway designs, the deflectometer should be set to deliver a 9,000-pound test load that corresponds to one half of an 18,000-pound standard dual axle load (ESAL).

Selecting Test Locations

When possible, select test locations as an average representation of the present surface condition and where the original pavement structure is free from patching. If alligator cracking is not prevalent, adjust test locations to avoid the cracking. If alligator cracking cannot be avoided, note it in the data. If alligator cracking is prevalent, assume a reduced modulus (contact your regional materials engineer). Select a test section to represent each type of terrain the project passes through.

Choose a minimum of 20 evenly spaced deflection test locations within a selected mile. If you suspect a pavement structure is frost-susceptible, consider increasing the number of tests. It is preferable to mark the test locations with paint for repeated testing of exact points in subsequent weeks. White painted markings on the centerline have been found to last longer and are easier to locate by field crews.

When to Test

Perform deflection testing during the spring thaw period when pavement strength is at a minimum. A weekly set of deflection tests should begin when the pavement structure begins to thaw and must continue through the period when peak deflections occur. Perform at least one set of readings in the summer and another in the fall. A rough guide showing when to begin deflection testing is offered below.

Table 5-5. Guide for Period of Deflection Testing

Maintenance Region	Begin Testing
Interior	2nd week in April
Central	1st week in April
Southcentral	South of Thompson Pass = 1st week in March
Southcentral	North of Thompson Pass = 1st week in April
Southeastern	Indeterminate; thaw must be closely monitored.

Base the decision of when to begin testing on actual field evidence, such as small test pits, frost tubes, or soil temperature data, if available. If you cannot perform deflection testing during the peak period, contact the regional materials engineer for a seasonal adjustment factor.

Testing during periods when night temperatures are below freezing should not begin before late morning. This is to prevent the bridging effect of the temporarily frozen surface layer from depressing the true rebound deflection readings.

Testing Procedure
See the falling weight deflectometer operation manual.

Safety Equipment and Precautions
Because of frequent stops, take all necessary safety precautions. Use appropriately attired flaggers as necessary to control traffic. High-level warning devices, such as vehicle-mounted arrow boards, are best (see the FHWA manual part VI, *Standards and Guides for Traffic Controls for Street and Highway Construction, Maintenance, Utility,* for detailed procedures). One or two vehicles with warning signs will be required, depending on traffic levels and sight distances.

5.4. Miscellaneous Materials Requirements

5.4.1. Required Asphalt Concrete Mix Design Properties (Marshall Method)

The following asphalt concrete Marshall Mix Design properties are required based on highway design ESAL levels.

Table 5-6. Mix Design Requirements

Marshall Mix Design Test Property	ESALs >1,000,000	ESALs <1,000,000 & >10,000	ESALs <10,000*
	Class A	Class B	Class C
Compaction Blows	75 Blows/Face	50 Blows/Face	35 Blows/Face
Stability (lbs), min.	1,800	1,400	1,000
Voids Total Mix (%)	2–5	2–5	1–5
Flow (0.01 in)	8–14	8–16	8–16

* Includes parking areas, bike paths, etc.